PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 : B41J 2/175 — A1

(11) International Publication Number: WO 92/18335

(43) International Publication Date: 29 October 1992 (29.10.92)

(21) International Application Number: PCT/US92/03074

(22) International Filing Date: 15 April 1992 (15.04.92)

(30) Priority data:
3/85295 17 April 1991 (17.04.91) JP

(71) Applicant *(for all designated States except US)*: EASTMAN KODAK COMPANY [US/US]; 343 State Street, Rochester, NY 14650-2201 (US).

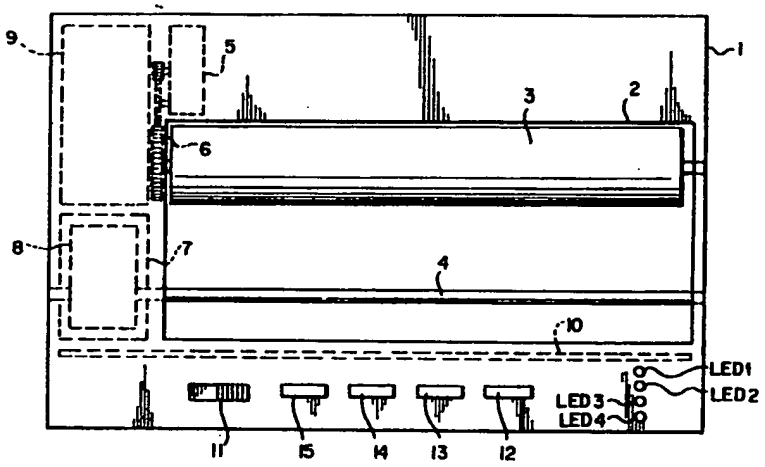
(72) Inventors; and
(75) Inventors/Applicants *(for US only)* : UOZUMI, Satoru [JP/JP]; 1540-2, Nakasu, Suwa-shi, Nagano-ken (JP). YAMADA, Morihiko [JP/JP]; 3228-3, Osachi, Okaya-shi, Nagano-ken (JP). HANAOKA, Ichiro [JP/JP]; 2-36, Minato 5-chome, Okaya-shi, Nagano-ken (JP).

(74) Agent: KURZ, Warren, W.; 343 State Street, Rochester, NY 14650-2201 (US).

(81) Designated States: AT (European patent), BE (European patent), CH (European patent), DE (European patent), DK (European patent), ES (European patent), FR (European patent), GB (European patent), GR (European patent), IT (European patent), LU (European patent), MC (European patent), NL (European patent), SE (European patent), US.

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: INK RESIDUAL QUANTITY SENSOR OF INK JET PRINTER



(57) Abstract

At the time of printing, the number of dots actually printed is stored in printed dot number storage means (28). At each operation of priming means (9), quantity of suctioned ink is cumulatively stored as a number of printed dots in printed dot number storage means (28) by means of storage control means (30). When it is desired to check residual quantity, ink residue detection means (31) computes it based on the ratio of a number of printable dots corresponding to the full volume capacity of ink cartridge (8) and the number of printed dots stored in printed dot number storage means (28). According to the present invention, an ink jet printer, which has a head having a head nozzle to eject ink for printing, ink cartridge (8) containing ink and priming means (9) to suction ink while applying pressure to the head nozzle, is provided with an ink residual quantity sensor characteristically having printable dot number storage means (27) to store a number of printable dots corresponding to the full volume capacity of said ink cartridge (8), printed dot number storage means (28) to store a number of dots actually printed by the head, storage control means (30) to cause quantity of the ink which has been suctioned to be cumulatively stored as a number of printed dots in printed dot number storage means (28) for each action of priming means (9), and ink residue detection means (31) which computes the residual quantity of ink based on said numbers of printable dots and printed dots.

Best Available Copy

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	ES	Spain	MC	Madagascar
AU	Australia	FI	Finland	ML	Mali
BB	Barbados	FR	France	MN	Mongolia
BE	Belgium	GA	Gabon	MR	Mauritania
BF	Burkina Faso	GB	United Kingdom	MW	Malawi
BG	Bulgaria	GN	Guinea	NL	Netherlands
BJ	Benin	GR	Greece	NO	Norway
BR	Brazil	HU	Hungary	PL	Poland
CA	Canada	IT	Italy	RO	Romania
CF	Central African Republic	JP	Japan	RU	Russian Federation
CG	Congo	KP	Democratic People's Republic of Korea	SD	Sudan
CH	Switzerland	KR	Republic of Korea	SE	Sweden
CI	Côte d'Ivoire	LI	Liechtenstein	SN	Senegal
CM	Cameroon	LK	Sri Lanka	SU	Soviet Union
CS	Czechoslovakia	LU	Luxembourg	TD	Chad
DE	Germany	MC	Monaco	TG	Togo
DK	Denmark			US	United States of America

INK RESIDUAL QUANTITY SENSOR OF INK JET PRINTER

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

The present invention relates to apparatus for sensing and displaying the amount of ink remaining in an ink cartridge of the type used in a conventional ink jet printer.

DESCRIPTION OF THE PRIOR ART

Conventional ink jet printers operate to print information on paper by selectively projecting drops of liquid ink supplied by an ink cartridge. Some of these printers are able to detect depletion of ink in order to prevent running out of ink during the process of printing. For example, detection of ink depletion has been heretofore done by means of a pair of electrodes so placed inside the ink cartridge that current between the electrodes is terminated when the ink level comes down below the electrodes. Another scheme is to place a magnetic float on the surface of the ink so that when the float comes down as the ink is depleted, it is detected by a magnetic sensor attached to the side of the ink tank, thereby making it possible to detect a shortage of ink.

As described above, some conventional devices detect depletion of ink directly by the lowering of the ink level. Therefore, it is necessary to provide a cartridge with electrodes, a magnet float or other similar parts, which makes an ink cartridge costly. Further, with the above schemes, it is not possible to detect the residual quantity of ink, but only to detect a shortage of ink just before the ink contained in the ink cartridge runs out.

U.S. Patent No. 4,714,937 to G.T Kaplinsky briefly mentions a concept of determining the level of ink in an ink supply by counting the number of nozzle firings. But this approach does not take into account the considerable volume of

ink that may be sucked through the printhead during an ink-priming operation to remove ink clogs and the like from the printing nozzle(s).

SUMMARY OF THE INVENTION

Regarding the above problems, the present invention has as an objective the provision of an ink residual quantity sensor for an ink jet printer capable of accurate detection of the residual quantity of ink in an ink cartridge without increasing cost of the ink cartridge.

According to the present invention, during the printing operation of an ink-jet printer, a number representing the number of dots actually printed by the printhead is stored in a first storage device. With each action of an ink priming means which serves to suction a predetermined quantity of ink through the printing nozzle(s), a storage control device serves to add to the stored number of dots actually printed a number representing the number of dots that could have been printed by the suctioned quantity of ink. The residual quantity of ink in the cartridge is determined by an ink residue detection means which compares (a) the sum of the number of dots actually printed and the number of dots which can be printed by the suctioned quantity of ink with (b) a number representing the number of dots which are printable by a full volume capacity of ink cartridge 8, such number of printable dots also being stored in a storage device. The result of this comparison is displayed by a gauge or the like on the printer housing, or by printing a display representing the residual quantity of ink on a sheet of paper.

The invention and its advantages will be better understood from the ensuing detailed description of preferred embodiments, reference being made to the accompanying drawings.

BRIEF DESCRIPTION OF THE PRIOR ART

Figure 1 is a top plan view of an ink jet printer.

Figure 2 is a block diagram showing an embodiment of an ink residual quantity sensor of an ink jet printer according to the present invention.

Figure 3 is a flow chart illustrating various steps of a program for implementing the method of the invention.

Figure 4 is an explanatory drawing showing an example of display of residual quantity of ink.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

A preferred embodiment of the present invention is explained hereunder, referring to the drawings.

Fig. 1 shows a top plan view of an ink jet printer. An opening 2 is formed in the upper surface of the printer housing 1, and a roller platen 3 and guide axis 4 are provided in parallel to each other within opening 2. Platen 3, which is rotatably supported, is rotated by the driving power of a stepping motor 5 through a plurality of gears 6. A carriage 7, which is moved laterally by the driving power of a stepping motor (not shown), is movably attached to guide axis 4. Replaceably attached to carriage 7 is an ink cartridge 8 which contains specified quantity of ink and is integrally provided with a printhead having a head nozzle to eject ink.

An ink priming means 9 is attached to one end of platen 3. In the same manner as disclosed in published Japanese Patent Application No. 275709/1990, priming means 9 has a precision pumping mechanism which enables it to precisely control the quantity of ink it suctions with a single pumping action. Such mechanism comprises a pump, a stepping motor to drive this pump and a cap member having a tube connected to the suctioning end of the pump. When carriage 7 is positioned opposite or in front of the priming means 7, the cap covers the head nozzle in order to prevent drying up of ink on the nozzle, and a negative

pressure is applied by the pump to the head nozzle in order to suction ink therefrom, thereby preventing the nozzle from clogging up. Further, this priming action is performed automatically when an ink cartridge is replaced, or after a predetermined amount of printing has been done (e.g. 50 pages of printing), or whenever it is desired to do so., such as by depressing a switch 12.

A printed circuit board 10 having a control circuit, which is described later, is positioned as shown in the printer housing. The printer housing is also provided, on the upper surface thereof, with power switch 11 and a plurality of operation switches 12 through 15. Optionally, a set of light-emitting diodes LED1 - LED4 can be mounted atop the printer housing to display, for example, the residual amount of ink in a cartridge and/or different selected printing fonts.

Fig. 2 is a block diagram of the control circuit on the aforementioned printed circuit board. Numeral 21 denotes a control unit for inputting printing data. It controls the printing operation by controlling a head driving unit 22 which drives the printhead, a carriage driving unit 23 which drives the stepping motor of carriage 7, and a paper feeder driving unit 24 which drives the stepping motor 5 of platen 3. Control unit 21 also performs ink priming by controlling a pump driving unit 25 which drives the stepping motor of the pump of priming means 9.

Connected to control unit 21 is a memory unit 26 having a first storage means 27 for storing a number representing the total number of printable dots, which can be computed from the full volume capacity of ink cartridge 8, a second storage means 28 for storing a number representing the total number of dots actually printed by the printhead, as well as the number of drops that could have been printed by the ink suctioned through the print head during the priming operation(s), and a counter 29 for counting a number of dots printed on a single line. Storage means 27 and 28 comprise nonvolatile memories.

Control unit 21 comprises a suitably programmed microprocessor which enables it to function as (i) a storage control means 30 for causing, at each operation of priming means 9, the number of dots that could have been printed from a quantity of suctioned ink to be added to the number of actually printed dots stored in storage means 28; (ii) an ink residue detection means 31, which computes the residual quantity of ink based on respective numbers of printable and actually printed dots stored in storage means 27 and 28, respectively; and (iii) a display output means 32 for causing the computed residual quantity of ink to be displayed.

The operation of the apparatus discussed above is explained hereunder, referring to Fig. 3. The explanation begins from the stage for replacing ink cartridge 8 with a new one (Step 4).

The change mode begins when power switch 11 is turned on with switch 12 held down (Step 5). Since carriage 7 is always positioned opposite the priming means 9 except while printing, it is not generally possible to physically reach the ink cartridge 8 for the purpose of replacement. When the change mode has commenced, however, control unit 21 drives the stepping motor through carriage driving unit 33, thereby moving carriage 7 to the center of the printing range (Step 6) so that ink cartridge 8 can be replaced.

Then, the operator releases the mechanical lock which holds the cartridge on the carriage, replaces ink cartridge 8 with a new cartridge and sets the mechanical lock again (Step 7).

After changing the cartridge, when switch 12 is turned on (Step 8), control unit 21 clears the memory in printed dot number storage means 28 and causes carriage 7 to be moved to a position opposite priming means 9 (Step 9). When carriage 7 has moved to this position, the cap member covers the head nozzle, and priming is performed under this condition (Step 10). Control unit 21

drives the stepping motor of the pump through pump driving unit 25 and, using the action of the pump, applies negative pressure to the head nozzle to suction ink.

Since the quantity of suctioned ink can be represented as a number of printed dots, such number can be stored in storage means 28 by control unit 21 functioning as storage control means 30 (Step 11).

In the above description, the printer was set at the change mode at Step 5. In case ink cartridge 8 is not to be changed, however, by turning off power switch 11, carriage 7 can be moved to the priming position opposite priming means 9, thereby returning the printer to the stand-by mode (Steps 12 and 13). The power is cut off thereafter.

Next, the function when printing is in progress is explained.

When paper has been set at platen 3 and a command to start printing is given, any counted value by counter 29 is cleared and one line of image information is printed (Step 14). Printing is done with ink ejected onto the paper from the head nozzle, while carriage 7 is moving. At that time, the number of dots actually printed by the head is counted by counter 29.

When a line of printing has been completed, the number of printed dots counted by counter 29 is cumulatively stored in printed dot number storage means 28 (Step 15).

Printing is performed with Steps 14 and 15 being repeated as above.

When a number of printed pages has reached 50 in total (Step 16), carriage 7 is moved automatically to the front of priming means 9 (Step 17) to receive the priming action described above (Step 18).

The quantity of ink suctioned by the above priming action is converted to a number of printed dots, and this number is stored in printed dot number storage means 28 by the storage control means 30 of control unit 21 (Step 19).

If the current printing operation has not yet been completed, the printer is returned to Step 14, from which the process is resumed (Step 20).

Next, the explanation is given as to the procedure of checking the residual quantity of ink prior to printing.

The operator turns on power switch 11 while holding down switch 14 (Steps 1 and 2), thereby setting the printer at the test mode. Paper should be set on platen 3 beforehand.

Control unit 21 determines, using its function as ink residue detection means 31, the residual quantity of ink by comparing the number of printable dots stored in printable dot number storage means 27 with the number of actually printed dots (which includes the dots that could have been printed by the suctioned ink), which was input in printed dot number storage means 28 in the manner described above. Then, using its function as display output means 32, control unit 21 causes the value of ink residual quantity to be displayed.

According to a particularly preferred embodiment of the present invention, the residual quantity of ink is printed on paper. As it is shown in Fig. 4, it is indicated as a bar graph whose length represents residual quantity of ink in relation to the length representing the full volume capacity (Step 3).

Therefore, residual quantity of ink can be easily confirmed by checking the display of the residual ink quantity. Thus, it is possible to accurately estimate the time when ink cartridge 8 should be changed.

If it is found necessary to change ink cartridge 8, the operator should proceed to Step 5 to change the cartridge. In cases where replacement is not necessary, he may proceed to Step 14 to start printing.

As described above, ink cartridge 8 is not provided with special parts for detecting residual quantity of ink, and, therefore, its cost can be kept low. Further,

detection of residual ink quantity can be conducted through software in a microcomputer incorporated in an ink jet printer.

Priming action can be actuated by a manual command by operating switch 12 when power switch 11 is at the "on" position.

The manner of displaying residual quantity of ink is not restricted to the aforementioned manner that calls for printing on paper; it may be indicated by means of a liquid crystal display or a lamp. Alternatively, the output of the residual ink detector can be used to energize one or more of the LED's (LED1-LED4), the more LED's energized, the greater the quantity of ink remaining in the cartridge.

According to the present invention, the number of dots actually printed is stored in a printed dot number storage means, and, whenever priming is performed, the quantity of suctioned ink is also cumulatively stored as a number of printed dots. By comparing the sum of these numbers with a number representing the total number of dots which are printable from a full ink cartridge, it is possible to accurately display the residual quantity of ink in the ink cartridge. Furthermore, this effect can be achieved by means of ink jet printer software without increasing cost of an ink cartridge.

We claim:

1. An ink residual quantity sensor of an ink jet printer provided with a head having a head nozzle to eject ink for printing, an ink cartridge containing ink and a priming means to suction ink while applying pressure to the head nozzle, said residual quantity sensor characteristically comprising:

a printable dot number storage means to store a number of printable dots corresponding to the full volume capacity of said ink cartridge;

a printed dot number storage means to store a number of dots actually printed by said head;

a storage control means to cause quantity of the ink which has been suctioned to be cumulatively stored as a number of printed dots in said printed dot number storage means for each action of said priming means; and

an ink residue detection means which computes the residual quantity of ink based on said numbers of printable dots and printed dots.

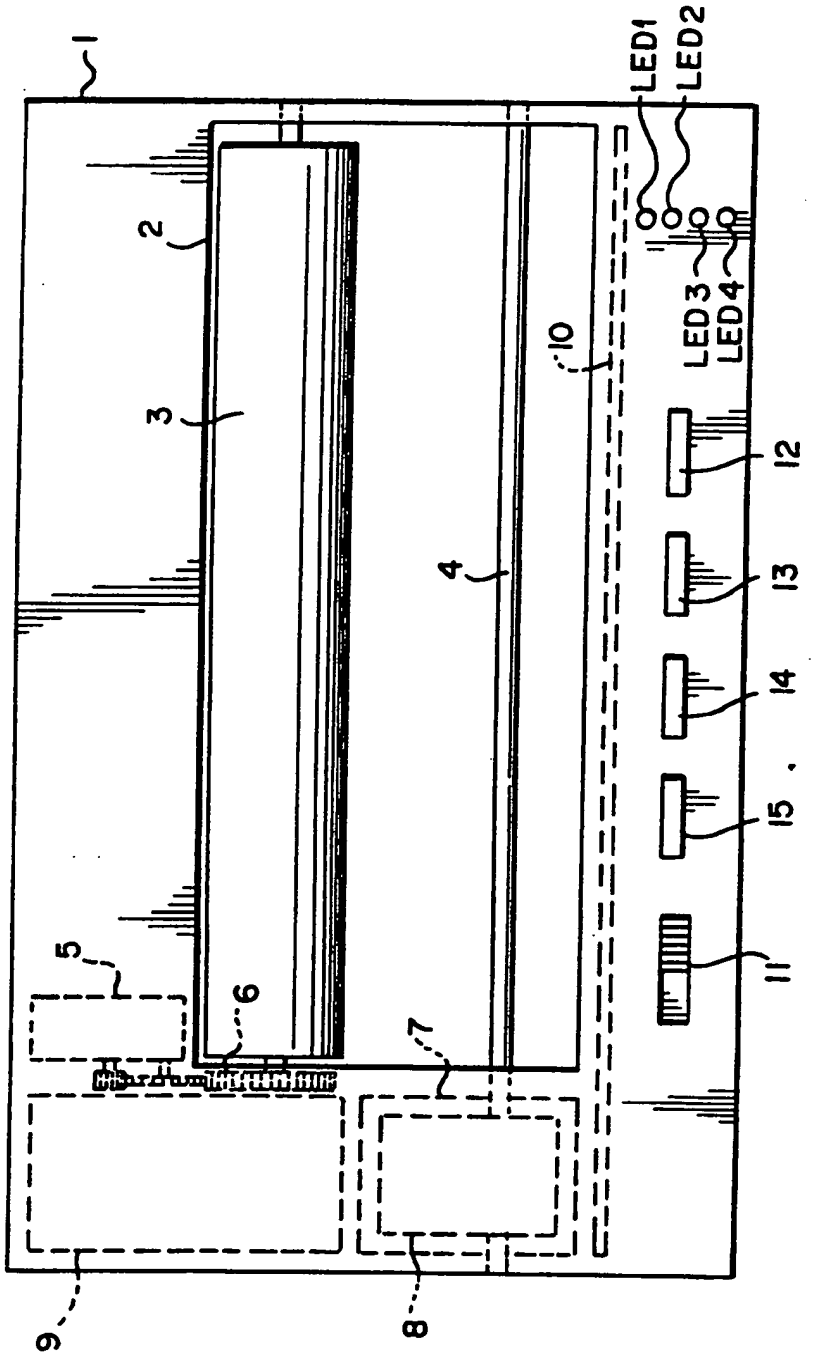


FIG. 1

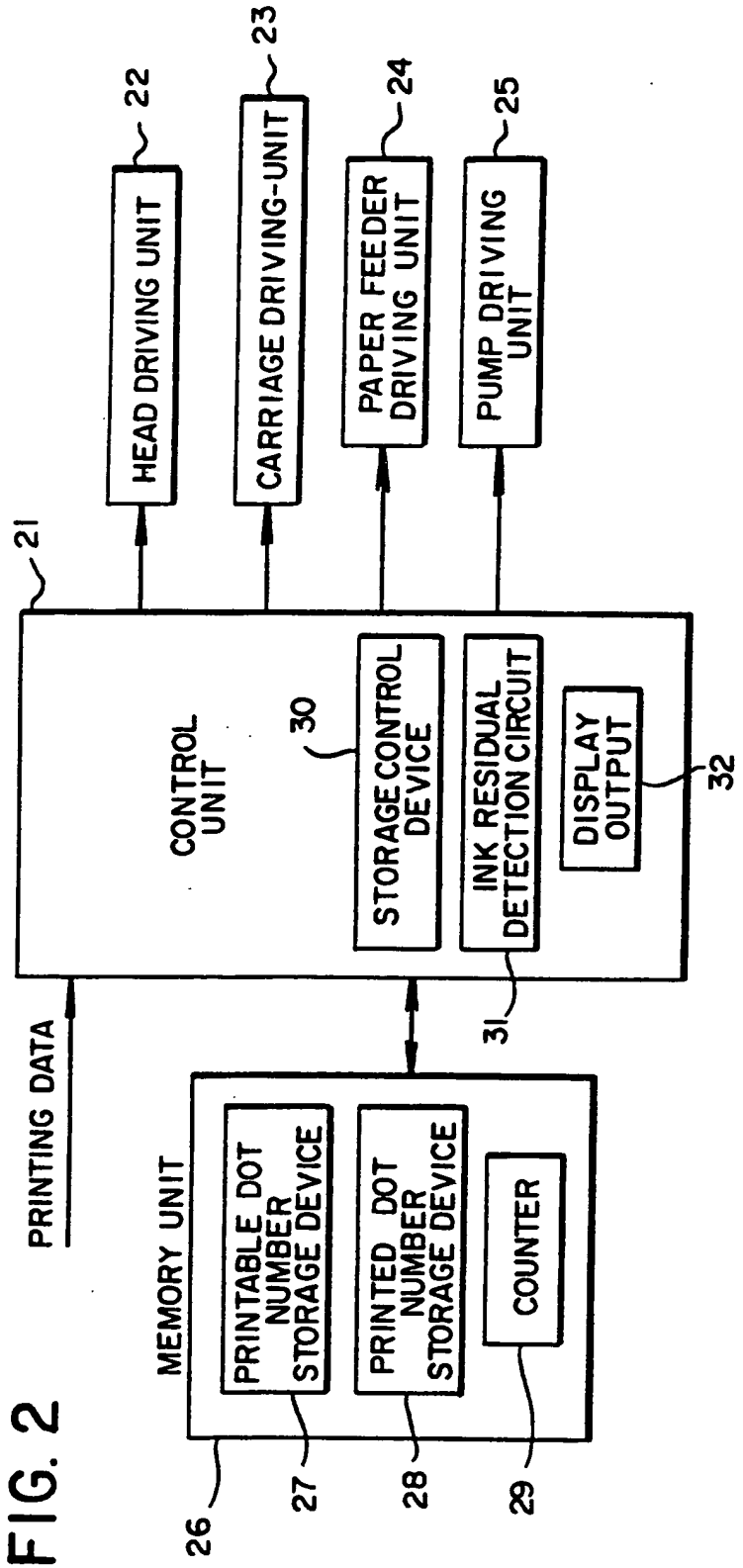

22
23
24
25
HEAD DRIVING UNIT
CARRIAGE DRIVING-UNIT
PAPER FEEDER DRIVING UNIT
PUMP DRIVING UNIT
21
CONTROL UNIT
30
STORAGE CONTROL DEVICE
INK RESIDUAL DETECTION CIRCUIT
DISPLAY OUTPUT
32
31
PRINTING DATA
MEMORY UNIT
PRINTABLE DOT NUMBER STORAGE DEVICE
PRINTED DOT NUMBER STORAGE DEVICE
COUNTER
26
27
28
29

FIG. 2

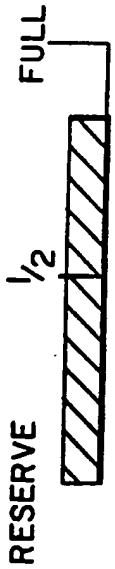

FULL
1/2
RESERVE

FIG. 4

WO 92/18335 PCT/US92/03074

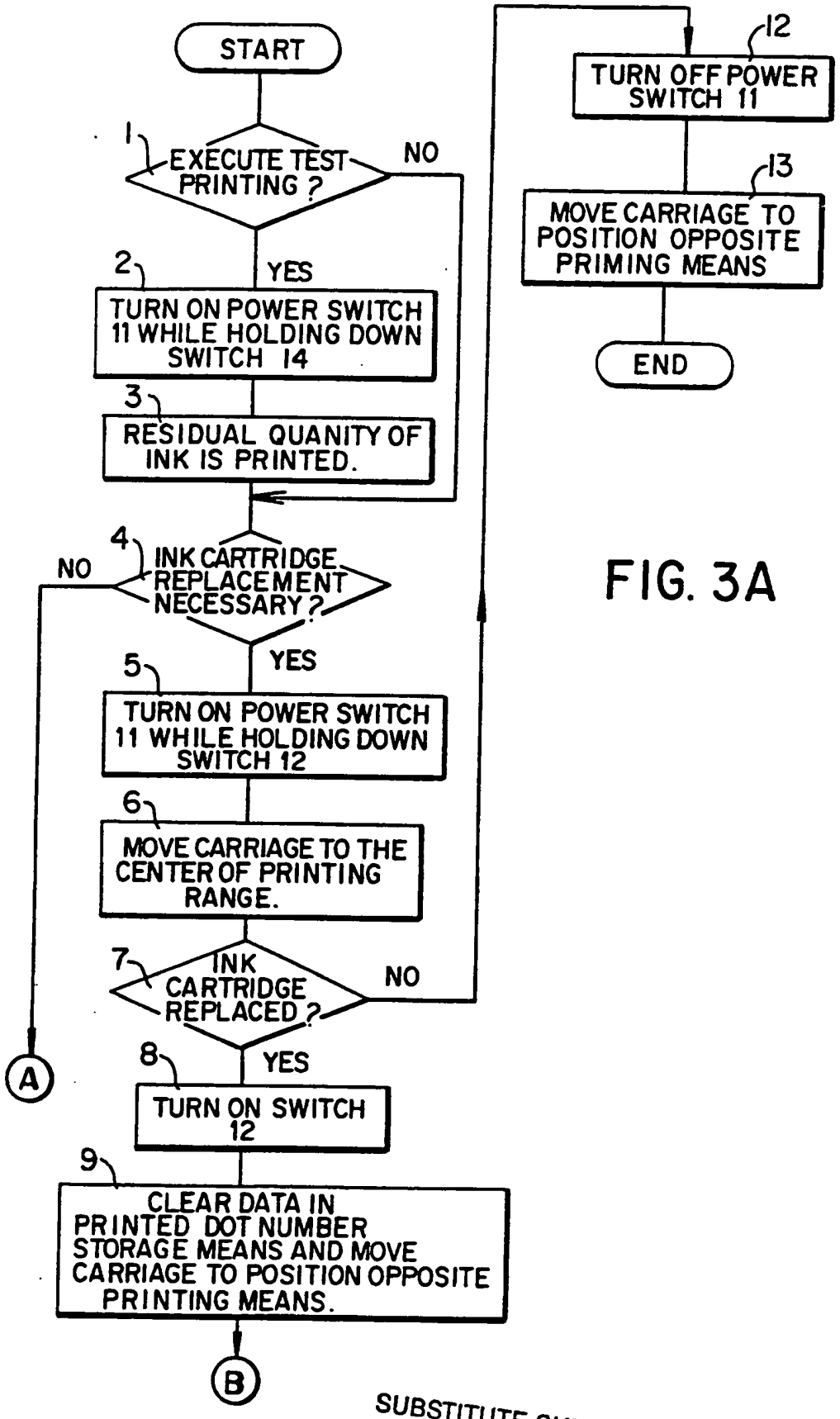
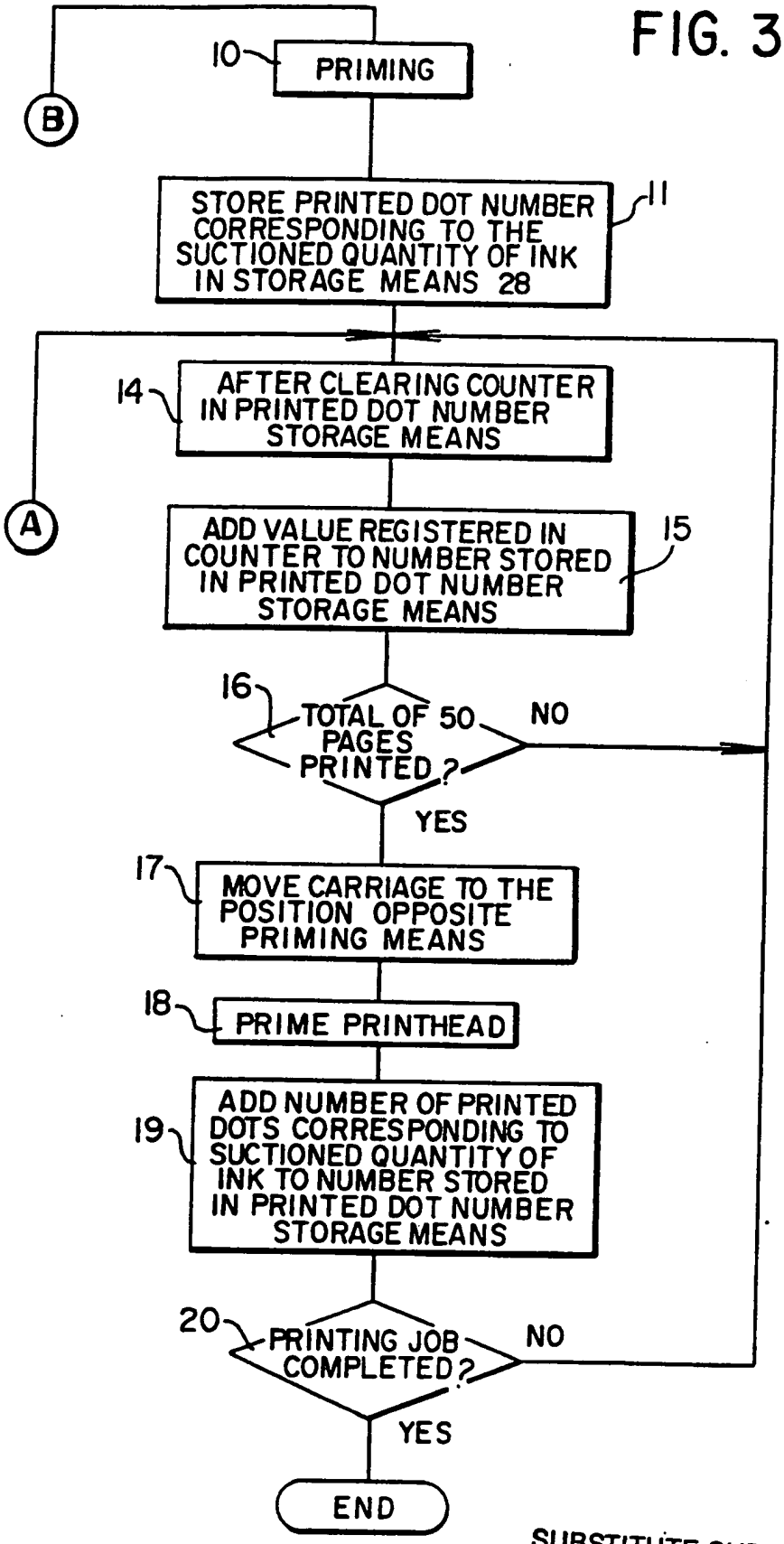


FIG. 3A

WO 92/18335 PCT/US92/03074

FIG. 3B



INTERNATIONAL SEARCH REPORT

International Application No PCT/US 92/03074

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC[5]: B 41 J 2/175

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC[5]	B 41 J,G 01 F

Documentation Searched other than Minimum Documentation to the Extent that such Documents are included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category [10]	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
A	WO, A1, 90/00 974 (SIEMENS AKTIENGESELLSCHAFT) 08 February 1990 (08.02.90), see fig. 1; abstract; page 8, lines 1-15; page 10, lines 6-8. --	1
A	EP, B1, 0 086 061 (IMPERIAL CHEMICAL INDUSTRIES PLC) 24 June 1987 (24.06.87), see claims 1,6. ----	1

* Special categories of cited documents: [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
12 August 1992	04 SEP 1992
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	MEISTERLE e.h.

ANHANG — ANNEX — ANNEXE

zum internationalen Recherchenbericht über die internationale Patentanmeldung Nr.

to the International Search Report to the International Patent Application No.

au rapport de recherche international relatif à la demande de brevet international n°

PCT/US 92/03074 SAE 59897

In diesem Anhang sind die Mitglieder der Patentfamilien der im obengenannten internationalen Recherchenbericht angeführten Patentdokumente angegeben. Diese Angaben dienen nur zur Unterrichtung und erfolgen ohne Gewähr.

This Annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The Office is in no way liable for these particulars which are given merely for the purpose of information.

La présente annexe indique les membres de la famille de brevets relatifs aux documents de brevets cités dans le rapport de recherche international visée ci-dessus. Les renseignements fournis sont donnés à titre indicatif et n'engagent pas la responsibilité de l'Office.

Im Recherchenbericht angeführtes Patentdokument Patent document cited in search report Document de brevet cité dans le rapport de recherche	Datum der Veröffentlichung Publication date Date de publication	Mitglied(er) der Patentfamilie Patent family member(s) Membre(s) de la famille de brevets	Datum der Veröffentlichung Publication date Date de publication
WO A1 9000974	08-02-90	EP A1 433280	26-06-91
		JP T2 4500482	30-01-92
EP B1 86061	24-06-87	AT E 27944	15-07-87
		AU A1 10841/83	11-08-83
		AU B2 569245	28-01-88
		BR A 8300458	01-11-83
		BR A 8300558	08-11-83
		CA A1 1190629	16-07-85
		CA A1 1199419	14-01-86
		CA A1 1217547	03-02-87
		DE C0 3372202	30-07-87
		DK A0 488/83	31-01-83
		DK A 488/83	06-08-83
		DK B 161958	02-09-91
		DK C 161958	10-02-92
		EP A1 86030	17-08-83
		EP A1 86031	17-08-83
		EP A1 86061	17-08-83
		EP A1 86075	17-08-83
		ES A1 519522	01-11-84
		ES A5 519522	30-11-84
		ES A1 8500769	01-02-85
		GB A0 8302588	02-03-83
		GB A0 8302674	02-03-83
		GB A1 2114412	24-08-83
		GB A1 2115317	07-09-83
		GB B2 2115317	10-07-85
		GB B2 2114412	05-02-86
		HU B 189220	30-06-86
		IE B 54378	13-09-89
		IL A0 67722	15-05-83
		JP A2 58146465	01-09-83
		JP A2 58150457	07-09-83
		JP A2 58193255	10-11-83
		JP A2 59193755	11-11-83
		JP B4 4031939	27-05-92
		MX A 158371	27-01-89
		NZ A 203170	09-05-86
		US A 4553702	19-11-85
		US A 4629164	16-12-86
		ZA A 8300535	30-11-83
		AT E 32866	15-03-88
		AU A1 10342/83	11-08-83
		CA A1 1190630	16-07-85
		DE C0 3375901	14-04-88
		DK A0 440/83	31-01-83
		DK A 440/83	06-08-83
		EP A1 86029	17-08-83
		EP B1 86029	09-03-88
		ES A1 519525	01-10-84
		ES A5 519525	31-10-84
		ES A1 531175	01-01-85
		ES A1 8500091	01-01-85
		ES A5 531175	01-02-85
		ES A1 8502353	01-04-85
		GB A0 8300094	09-02-83
		GB A1 2115316	07-09-83
		HU A2 42914	28-09-87
		HU B 194681	28-03-88
		IE B 54377	13-09-89
		IL A0 67704	15-05-83
		JP A2 58146464	01-09-83
		MX A 158668	24-02-89

NZ	A	203003	04-05-86
SU	A3	1187699	23-10-85
US	A	4580721	08-04-86
ZA	A	8300305	26-10-83
AT	E	19340	15-05-86
DE	C0	3270700	28-05-86
EP	A1	58472	25-08-82
EP	B1	58472	23-04-86
GB	A1	2093732	08-09-82
GB	B2	2093732	12-06-85
US	A	4467961	28-08-84
AR	A1	227705	30-11-82
AU	A1	79945/82	19-08-82
AU	B2	554404	21-08-86
BR	A	8200693	14-12-82
CA	A1	1187584	21-05-85
DK	A	519/82	13-08-82
DK	A	4108/86	28-08-86
DK	A0	4108/86	28-08-86
EG	A	15799	30-03-87
EG	A	15799	30-03-88
ES	A1	509574	16-12-82
ES	A5	509574	14-01-83
ES	A1	8301581	01-04-83
HU	B	187640	28-02-86
IE	B	52901	13-04-88
IL	A0	64980	30-04-84
IL	A1	64980	30-06-85
JP	A2	57159567	01-10-82
JP	B4	3022221	26-03-91
MX	A	158890	29-03-89
NZ	A	199580	13-09-85
SU	A3	1099829	23-06-84
ZA	A	8200563	29-12-82
ZW	A	17/82	31-08-83

This Page is Inserted by IFW Indexing and Scanning Operations and is not part of the Official Record

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☐ BLACK BORDERS
- ☐ IMAGE CUT OFF AT TOP, BOTTOM OR SIDES
- ☐ FADED TEXT OR DRAWING
- ☐ BLURRED OR ILLEGIBLE TEXT OR DRAWING
- ☐ SKEWED/SLANTED IMAGES
- ☐ COLOR OR BLACK AND WHITE PHOTOGRAPHS
- ☐ GRAY SCALE DOCUMENTS
- ☐ LINES OR MARKS ON ORIGINAL DOCUMENT
- ☑ REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY
- ☐ OTHER: _____

IMAGES ARE BEST AVAILABLE COPY.
As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.